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EQUIPMENT FOR THE TESTING OF LARGE-CAPACITY SCALES

This Letter Circular has been prepared for the purpose of summarizing the experience and observations of the National Bureau of Standards relative to power-operated equipments specially designed for the testing of large-capacity scales. It is recognized that official jurisdictions and other agencies procuring such equipments must frequently be guided by considerations of cost, availability of parts, local conditions, special uses for the equipments, and the like. Therefore, in the material which follows, the effort will be to point out certain important design factors and offer certain suggestions, such that the designer of a particular equipment may be in a position to adapt to his particular needs what will most effectively serve his purpose.

The National Bureau of Standards has no set of specifications for a vehicle-scale testing equipment except the one which was used in the procurement of its own vehicle-scale testing unit. The Bureau does not recommend these specifications for the reasons mentioned below, but the operation of this unit and observation of units which are in operation in the States suggest some general conclusions.

The vehicle-scale testing unit of the National Bureau of Standards is admittedly "overdesigned". That unit was deliberately built with very heavy parts and was provided with an unusually powerful engine because it was planned to use it in all sections of the United States, at all seasons of the year, at points frequently many miles from service stations, and under adverse conditions of roadways, temperatures, and elevations. In order to obtain what was believed to be essential strength and power, one important principle was sacrificed, namely, that the unloaded weight of the vehicle should not exceed the value of the test-weight load carried.

For a unit which is to be operated within the confines of a single State, county, or city, the heavy construction of the Bureau unit need not be duplicated. It is definitely recommended that a unit be so designed that the unloaded weight of the vehicle--that is, exclusive of the large-denomination test weights--be less (preferably only slightly less) than the total value of such test weights. The reason for this is to avoid a break in the test when the unloaded vehicle is used as a strain load in combination with the test-weight load. If the strain load approximates but does not exceed the value of the test-weight load, the test may be carried out smoothly and without breaks to a value equivalent to the gross weight of the loaded equipment. On the other hand, if the value of the strain load exceeds the value of the test-weight load, there will be an interval corresponding to the difference between these two values within which the inspector cannot definitely determine the performance of the scale being tested, a situation which also introduces a degree of uncertainty with respect to subsequent test results based on the use of test weights.

It is desirable to have the testing unit as maneuverable as practicable, and to this end the unit should be designed with the shortest wheelbase consistent with the required load area. The cab-over-engine type of truck chassis is therefore recommended.

Experience has demonstrated that it is not necessary that a vehicle-scale testing equipment have more than one driving axle. Overloading of tires should be avoided, and not less than dual tires on a single rear axle or single tires on two rear axles should be provided.

Safety of operation is an important consideration. Adequate, power-operated service brakes should be provided for the truck, and an entirely independent emergency braking system operating on the wheels instead of the drive shaft is recommended. Weight-handling controls should automatically go into neutral position when released, and, when such controls are in neutral position, positive and effective braking or other positive means should automatically be brought into play to prevent movement of weights or elements of the weight-handling mechanism. All movement of weights or weight-handling elements should result only from the application of power; for example, the lowering of weights by gravity, with the mechanism in a free-running condition and movement controllable only by braking, is a dangerous operation, and the weight-handling mechanism should be designed to make this impossible. Safety of operating personnel should be kept in mind when deciding upon factors such as details of body design and location of weight-handling controls.

It is recommended that the truck transmission be designed to provide four forward speeds. The lowest gear ratio should permit very slow movement of the truck, and the highest gear ratio should be a direct drive or an overdrive to provide economy of operation under favorable driving conditions on relatively level roads.

For the protection of the operating personnel, the cab should be fully enclosed and should be well ventilated.

The design of the mechanical means for handling the large-denomination test weights and the design of the body are interrelated. The Bureau unit has the swinging-boom type of weight-handling equipment and has an open body; this combination is preferred because it provides greater facility in the placement of the test weights as these are unloaded from the truck and in the re-loading of the equipment after a test has been completed, with consequent economy of time and effort. A considerable number of the vehicle-scale testing equipments in use by State jurisdictions are of the fixed-track type with enclosed bodies. An enclosed body provides desirable protection for the test-weight load and the weight-handling apparatus (which may be almost a necessity if the unit is to be operated during bad winter weather), and contributes to good appearance, but has the disadvantage that this type is not as convenient as the open type for the operator and, of course, it precludes the use of a swinging boom.

A third general design has been in successful use in one State for a number of years. This design utilizes an enclosed body and a fixed track, but differs from conventional design in that the test weights are of relatively large denomination and are movable on the scale platform by means of an electrically-powered dolly which is itself a test weight.

Whatever general type of unit is adopted, mechanical means must be provided for handling the large-denomination test weights, and it is strongly recommended that the weight-handling equipment be power-operated throughout. In deciding upon the source of power for the weight-handling apparatus, consideration should be given to the use of electricity. This has certain advantages over power derived directly through a power take-off from the truck power plant. If the necessary units can be obtained, it is practicable to provide for the operation of the weight-handling apparatus from any convenient 110-volt commercial outlet, using a reeled cable 100 feet or more in length to make the connection; for locations where commercial outlets cannot be reached, such equipment can be powered by means of a generator operated by the truck engine or by an auxiliary engine. Hydraulic operation is provided in units operated by two States and one county.

In the case of test weights of 500-pound and 1000-pound denominations, the weight-handling mechanism should be designed to handle several weights at one time under any ordinary out-of-level condition of the truck, in order to reduce the time required to load and unload the weights for each test.

A very important decision to be made in preparation for the design of an equipment is the amount of test-weight load to be carried. It is recommended that not less than 10,000 pounds of large-denomination test weights be utilized in the test of motor-truck scales, and that this total be increased to 15,000 pounds, or even to 20,000 pounds, if practicable. A unit carrying a 20,000-pound load is hardly to be recommended in the case of a State equipment intended to operate in all sections of the State, because roads and bridges may be encountered which will not safely accommodate a vehicle of such a large gross weight; such a load is practicable, however, where the unit is to be operated only on the principal highways or within the confines of a single city. It is recommended that, for equipments of conventional design, weights of 1000-pound denomination comprise the bulk of the test-weight load, but that at least two 500-pound weights be provided. It is considered advisable that at least some 50-pound weights be included, probably not less than ten; if it is intended that the unit test the smaller types of large-capacity scales in addition to vehicle scales, then it will be advisable to include from twenty to forty 50-pound weights.

Test weights should conform to National Bureau of Standards requirements for weights of Class C. Test weights cast by foundries without previous experience in such work are usually found to be unsatisfactory, and it is recommended that test weights be procured from firms (such as manufacturers of large-capacity scales) which are fully familiar with the specification requirements for test weights and which are experienced in manufacturing such weights. The weights should be designed to shed water, and there should be no openings around the lifting bars or any other cast-in elements. All outside surfaces should be brought to a reasonably smooth finish, and should be free from blow holes, porosity, shrinkage defects, cracks, and other injurious defects. Corners and edges should be rounded. The adjusting cavity should have but one opening--on one side of the weight--and the closure should be an acceptable "Class C closure." The weights should be finished with two coats of aluminum enamel. A sketch and drawings of the 1000-pound weights used on the unit of the National Bureau of Standards is appended; this design has proved very satisfactory in service.

The bureau tolerances for 500-pound and 1000-pound Class C test weights are as follows:

Denomination	Acceptance and Adjustment Tolerance	Maintenance Tolerance
500 lb	$\frac{1}{2}$ oz	1 oz
1000 lb	1 oz	2 oz

Suitable means must be provided to prevent shifting of the weights on the truck bed or loss of a weight from the truck, when the truck is in motion. In the NBS unit, a series of fabricated, hollow "mushrooms" of square cross section, 8-3/4 inches on a side at the floor level, 3 inches high, and with sides sloping at an angle of 60 degrees with the horizontal, is securely anchored to the truck bed to engage recesses in the bottoms of the weights. In addition, sturdy side boards and tail gate, 12 inches high, and a forward barrier are provided.

Manual means should be provided for shifting the positions of 1000-pound and 500-pound test weights on a scale platform. A sketch of the "cart" utilized by the Bureau for this purpose is appended. The tubular construction employed gives adequate strength and desired lightness.

Suitable cabinets should be provided to accommodate 50-pound test weights, sets of small weights, all auxiliary equipment, and the personal baggage of the inspectors. Means should be provided for locking cabinets and doors, and it is suggested that all such locks be master-keyed. Provision should be made for drainage of water from the truck bed. Vehicle lighting and reflectors should conform to local requirements.

The testing method for vehicle scales which utilizes "error" weights on the scale platform for the exact determination of scale errors not exceeding 50 pounds is recommended. For this purpose a set of Class C weights (grip-handle and knob) should form a part of the equipment; a good set of error weights is made up as follows: 20-20-20-10-10-5-5-2-2-2-1-1 lb. Since it is to be anticipated that at least some of the scales tested will be of the type utilizing counterpoise weights, a set of slotted counterpoise weights also should be provided; a set ranging from 10 pounds to 0.0001 pound, adjusted to Class B tolerances, so that the weights may be utilized not only for precise determination of the ratio errors of scales but also for the testing of the scale counterpoise weights, is recommended. Of course, a portable balance should be provided for the testing of the commercial counterpoise weights.

For the NBS unit, a fitted tarpaulin was originally provided to cover the test weights as protection against wetting during rain storms. The use of this cover was shortly discontinued for two reasons: First, its application, removal, and storage involved the expenditure of a considerable amount of time and labor. Second, protection of the weights against wetting was found to be unnecessary when it was determined that the value of one of the 1000-pound weights would be increased by only 0.2 pound as a result of thorough wetting and before any drainage had taken place. Use of a tarpaulin cover for an open body is to be recommended, therefore, only when this is necessary to prevent accumulations of snow and ice on weights and equipment.

Suitable auxiliary equipment such as jacks, pry and crow bars, level, wrenches and other small tools, flash lamps or electric lanterns for pit inspections, flares and other signaling devices, as required, for emergency use, shovel, saw, broom, and the like should be included.

There are in service in the United States many scale-testing equipments, of varying designs and carrying test-weight loads of varying amounts. During the summer of 1948, information was collected on State and local equipments in service or under construction; this survey was limited to equipments carrying test-weight loads of 10,000 pounds or more, and the information gathered is summarized in the tabulation which follows.

**SCALE TESTING EQUIPMENTS
CARRYING 10,000 POUNDS OR MORE OF TEST WEIGHTS**

Owned by:	In Use	Under Const.	Year Procured	Cab over Engine	Body	Fixed Track	Swinging Boom	Power for Handling Test Weights	Location of Handling Controls	Test Weights			
										50-lb	500-lb	1000-lb	Total
State of Alabama	1		48	No	Canopy	X		Truck Engine	Rear of Body	10	24		12,500
State of California	1		39	No	Open	X		Manual		70	13		10,000
do	1		40	No	Curtains	X		Manual		71	13	(a)	11,100
do	1		47	No	Open	X		Elec.	Movable	10	10		10,500
County of Alameda, Cal.	1		37					Enclosed trailer standardized at					10,000
County of Fresno, Cal.	1		47	No	Canopy	X		Manual		75	16		11,750
do	1		47					Enclosed trailer standardized at					20,100
County of Kern, Cal.	1		38	No	Encl.	X		Elec.	On Hoist	18	20		10,900
County of Los Angeles, Cal.	1		47	No	Open	X		Truck Engine	Rear of Body	40	8	4	10,000
do	1		38					Enclosed trailer standardized at					20,000
County of San Joachin, Cal.	1		47	No	Encl.			Manual		200			10,000
County of San Mateo, Cal.	1		46	Yes	Encl.	X		Manual		80	12		10,000
County of Santa Clara, Cal.	1		41	Trailer standardized at 10,000 lb						46			12,300
County of Stanislaus, Cal.	1		42	5000-lb Trailer				Elec.	On Hoist		10		10,000
State of Connecticut	1		41	No	Open	.	X	Truck Engine	Rear of Cab	10	24		24,500
District of Columbia	1		48	Yes	Open		X	Truck Engine	Rear of Cab	20	12		13,000

SCALE TESTING EQUIPMENTS
CARRYING 10,000 POUNDS OR MORE OF TEST WEIGHTS
(Continued)

Owned by:	In Use	Under Const.	Year Procured	Cab over Engine	Body	Fixed Track	Swinging Boom	Power for Handling Test Weights	Location of Handling Controls	Test Weights			
										50-lb	500-lb	1000-lb	Total
<u>State of Florida</u>	1		47	No	Open		X	Truck Engine	Rear of Cab	4	20	20,200	
<u>State of Georgia</u>	1		44	No	Encl.	X		Elec.	Rear of Body	10	20		10,500
<u>State of Idaho</u>	1		36	No	Encl.	X		Truck Engine	Rear of Body		14	3	10,000
<u>State of Illinois</u>	1		41	No	Encl.	X		Auxil. Engine	Rear of Body	50	10		12,500
do		1		No	Encl.	X		Truck Engine	Rear of Body	20	18		19,000
<u>City of Chicago, Ill.</u>	2		40	Yes	Encl.	X		Truck Engine	Rear of Body	20	10		11,000
<u>State of Indiana</u>	1		40	Yes	Encl.	X		Truck Engine	Rear of Body	20	10		11,000
<u>State of Iowa</u>	1		41	Yes	Encl.	X		Truck Engine	Rear of Body	20	4	8	11,000
<u>State of Kansas</u>	1		48	No	Encl.	X		Hydr.	Rear of Body	10	2	16	17,500
<u>State of Massachusetts</u>	1		31	No	Open		X	Truck Engine	Rear of Cab		30		15,000
<u>City of Boston, Mass.</u>	1		47	No	Open		X	Truck Engine	Rear of Cab	40	(b) 16		18,675
<u>State of Michigan</u>	2		39	No	Encl.	X		Truck Engine	Front of Bdy	10	10		10,500
<u>Dity of Detroit, Mich.</u>	1		43	Yes	Open		X	Truck Engine	Rear of Cab	40	2	14	17,000
<u>City of Lansing, Mich.</u>	1		36	No	Encl.	X		Truck Engine	Inside Bdy	40	10		12,000
<u>County of Washtenaw, Mich.</u>	1		37	No	Open	X		Hydr.	Front & Rear of Bdy		10		10,000
<u>State of Montana</u>		2		No	Encl.	X		Elec.	On Hoist	20	12		13,000
<u>State of Nebraska</u>	1		47	No	Encl.	X		Elec.	On Hoist	40	13		15,000
<u>State of New Jersey</u>	1		35	No	Encl.	X		Truck Engine	Inside Cab	32	23		13,100
do		1		No	Open		X	Truck Engine	Rear of Cab	40	2	20	23,000
<u>County of Union, New Jersey</u>	1		48	Yes	Encl.	X		Truck Engine	Cab and Body	15	10		10,750
<u>City of New York, New York</u>	1		35	Yes	Open		X	Truck Engine	Rear of Body	20	1	20	21,500

SCALE TESTING EQUIPMENTS
CARRYING 10,000 POUNDS OR MORE OF TEST WEIGHTS
(Continued).

Owned by:	In Use	Under Const.	Year Procured	Cab over Engine	Body	Fixed Track	Swinging Boom	Power for Handling Test Weights	Location of Handling Controls	Test Weights			
										50-lb	500-lb	1000-lb	Total
County of Monroe, New York	1		30	No	Open		X	Truck Engine	Rear of Cab	8	2	12	13,400
County of Nassau, New York	1		37	Yes	Open		X	Truck Engine	Rear of Cab	20	1	12	13,500
County of Suffolk, New York	1		45	No	Open		X	Truck Engine	Rear of Cab	8		16	16,400
State of North Carolina	1		47	No	Canopy	X		Hydr.	Rear of Body	10	2	16	17,500
do	1		39	No	Open	X		Truck Engine	Side of Body	10	2	10	11,500
State of North Dakota	2		40	No	Encl.	X		Elec.	On Hoist	60		7	10,000
State of Ohio	1		47	No	Encl.	X		Truck Engine	Rear of Body	20		10	11,000
State of Oklahoma	1		48	No	Open	X		Elec.	On Hoist	10		10	10,500
State of Pennsylvania	2		36	Yes	Open		X	Truck Engine	Rear of Cab	40	20	4	16,000
State of Tennessee	3		47	Yes	Open			Truck Engine	Rear of Body	10	20		10,500
State of Texas	1			No	Encl.	X		Elec.	On Hoist	20		(c)	11,000
do	1					Tractor-trailer		Elec.	On Hoist	20		(d)	21,000
State of Vermont	1		39	No	Open	X		Truck Engine	Rear of Cab	20	2	9	11,000
State of Virginia	1		47	Yes	Encl.	X		Truck Engine	Rear of Cab	20	20		11,000
City of Seattle, Wash.	1		42	Yes	Encl.	X		Truck Engine	Rear of Body	226		(e)	12,000
State of Wyoming	1		37	No	Open		X	Truck Engine	Rear of Cab	(f)	1	10	11,200
National Bureau of Standards	1		36	No	Open		X	Truck Engine	Rear of Cab	10		15	15,000

(a) "Miscellaneous" weights to value of 1,050 pounds.

(b) Three "weight carriers" and one "dolly," standardized, total 675 pounds.

(c) Electrically-powered dolly standardized at 2,500 pounds and three 2,500-pound weights.

(d) Electrically-powered dolly standardized at 5,000 pounds and three 5,000-pound weights.

(e) Two "carts," each standardized at 350 pounds.

(f) Also, two 100-pound weights.

(g) Up to forty 50-pound weights are carried upon occasion.

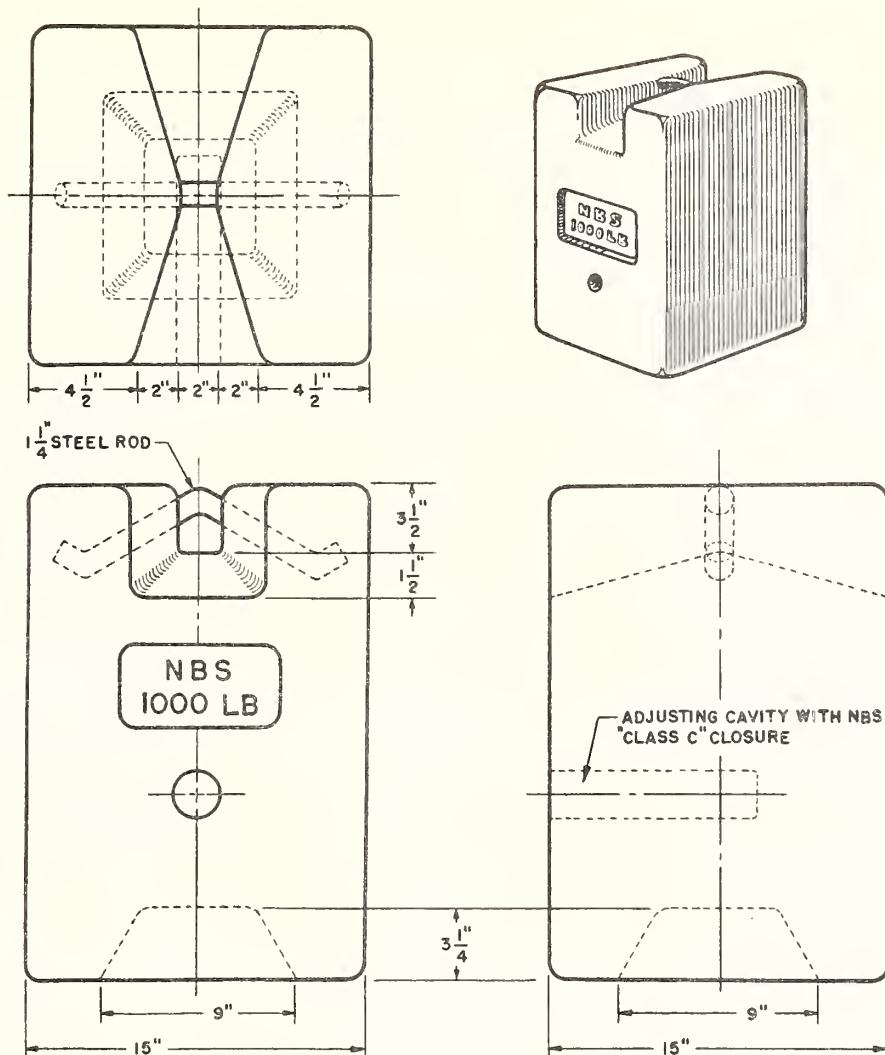
References.--For general information on inspection and testing methods and related matters, see National Bureau of Standards Handbook H37, "Testing of Weighing Equipment" (75 cents); Chapters 15-19, incl., of National Bureau of Standards Handbook H26, "Weights and Measures Administration (75 cents); pages 64-73, incl., of National Bureau of Standards Miscellaneous Publication M157, "Report of the Twenty-Sixth National Conference on Weights and Measures" (20 cents); and pages 75-79, incl., of National Bureau of Standards Miscellaneous Publication M161, "Report of the Twenty-Eighth National Conference on Weights and Measures (30 cents).

For illustrations and descriptions of some vehicle-scale testing units, see the following reports of the National Conference on Weights and Measures:

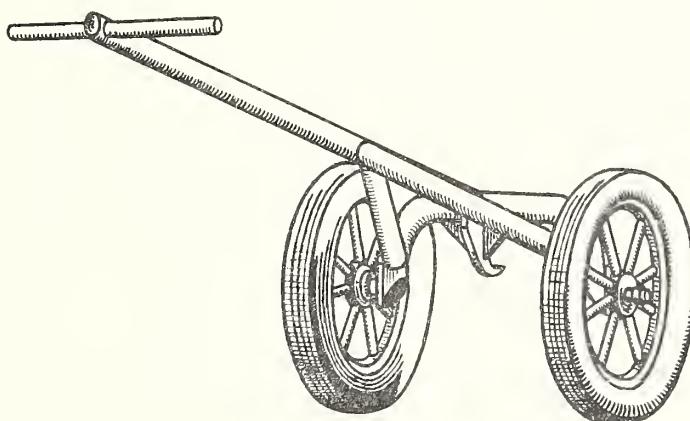
<u>NBS Publication</u>	<u>Price</u>	<u>Conference No.</u>	<u>Page Reference</u>
M129	50 cents	Twenty-Fourth	130-136
M156*		Twenty-Fifth	110-113
M157	20 cents	Twenty-Sixth	47-61
M159*		Twenty-Seventh	45;117-128
M161	30 cents	Twenty-Eighth	19-21; 99-103
M170	30 cents	Thirty-First	67-71

*Out of print.

(Copies of the publications cited above may be consulted at numerous State, technical, and public libraries throughout the country. Also, until stocks are exhausted, these publications may be obtained through purchase, at the prices indicated, from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.; proper remittance should accompany an order.)



NBS "CLASS C" 1000-POUND TEST WEIGHT



NBS HANDLING CART FOR 1000-POUND TEST WEIGHT

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